ASSESSING THE RETURNS TO INVESTMENT IN LIVESTOCK DISEASE CONTROL IN DEVELOPING COUNTRIES: A CASE STUDY FROM INDONESIA

I.W. Patrick and D.T. Vere

NSW Agriculture

Investment in agricultural technology is a major form of assistance to the developing countries. This support is consistent with the importance ascribed to agricultural technology in national economic growth. Because of resource pressures, there is an increasing need for prior assessments of the net benefits of such investment. An **ex ante** assessment of Australian aid to the improvement of livestock health technology in Indonesia is described in this paper.

1. Introduction

Investment in agricultural research and development is a major form of assistance to the developing countries. Where this investment results in improved technology which increases agricultural productivity, it is likely to have much broader national implications because of agriculture's central role in economic development (Mellor 1986). The growth in funding assistance for this purpose has introduced a requirement for complementary economic assessments (Davis, Oram and Ryan 1987; Antony and Anderson 1991), two main aspects of which are to establish goals for translation into viable research programmes, and to evaluate the benefits and costs of technology adoption (Hardaker, Anderson and Dillon 1984). In part, this requires a greater emphasis on the **ex ante** economic assessments of technology impacts (Ryan 1984).

While there are numerous examples of high payoffs to agricultural technology adoption in the developing countries, the individual experiences have been highly variable with clear successes and failures and a level of uncertain achievement. Hardaker, Anderson and Dillon identified a growing concern from both aid donors and recipients as to the returns from investment in this process and the need for the prior demonstration of potential payoffs to facilitate resource allocation. They made the distinction between the roles of **ex ante** analysis in guiding technology planning and programme management and **ex post** evaluation of past investment in technology to facilitate future policy formulation. This distinction is important because the end uses of these applications in the technology investment process differ, and they also have different procedural and informational requirements. The **ex ante** assessment need can also be attributed to resource pressures and is therefore seen as being an important input into the process of maximising aid effectiveness (Australian Government 1985).

The adoption of improved agricultural production technology offers opportunities for productivity gains, either from reducing unit production costs or increasing production capacities. These gains are likely to be sustainable where technology adoption results in the maintenance of improved production practices. Livestock production is an area in which productivity improvements from new technology can have significant national economic benefits in the developing countries. Income elasticities of demand for livestock products in these countries are high relative to other major food groups. For example, Sarma and Yeung (1985) reported income elasticities of demand for livestock and cereal products of 0.63 and 0.16 over all developing countries. Developing countries are also anticipated to face serious future meat supply-demand imbalances as incomes continue to rise. Sarma and Yeung concluded that an annual 5.1 per cent growth in domestic meat production would be required to meet southern Asia's projected annual per capita meat demand of 8.7 kg by the year 2000. By comparison, the annual growth rate for meat production in this region was 1.8 per in 1977. These trends reflect the increased assistance to improving the performance of the livestock sectors in these countries (Winrock 1986).

Technology options for achieving livestock productivity gains in modern livestock systems include the use of superior breeding stock, animal disease control and improved farm resource management. These gains have tended to diminish over time as the options for making productivity improvements become restricted because of the comparatively high status of the modern systems in terms of factors such as reproduction, growth rates and disease control. In contrast, the livestock resources in the developing countries remain relatively underdeveloped and the scope for effecting productivity improvements are much greater. Animal health is a relevant example where many major livestock diseases remain uncontrolled and seriously impact on livestock production.

An **ex ante** economic assessment of the control of the major livestock disease, Haemorrhagic Septicaemia (HS), in the eastern islands region of Indonesia is described in this paper. The background to the study is discussed in Section 2 which is followed by details of the assessment procedures adopted in Section 3. Section 4 discusses the results and the implications of these assessments for planning and funding agricultural aid.

2. Background

Through the Australian International Assistance Bureau (AIDAB), Australia has provided assistance to the development of improved livestock health technology in Indonesia over the past 25 years. One major focus of this assistance has been in the development of an integrated system for improving the delivery of veterinary services in Indonesia's eastern islands. Initially this involved facilitating the provision of a network of provincial and district laboratories to complement two major disease investigation centres in Bali and South Sulawesi, through the Eastern Islands Diagnostic Laboratories Project which operated between 1973 and 1982. In 1989, AIDAB extended this assistance by establishing the Eastern Islands Veterinary Services Project (EIVSP) which is to run until 1994.

The original project was concerned with the provision of laboratory structures while the EIVSP is attempting to make this system functional. This involves the training of both field and laboratory veterinarians and providing base equipment to facilitate staff operations. The main difference between the two projects is that the EIVSP has been more concerned with the development of the professional status of the local veterinarians services than with the provision of facilities. This has been effected locating two Australian veterinarians and an economist with the project and by complementing this input with short-term consultancies in specialist disciplines. The economic component of the EIVSP has three aspects, which are (i) to establish practical procedures for assessing the economic impacts of livestock diseases and the benefits and costs of government-sponsored control programmes, (ii) to quantify the economic factors affecting cattle productivity in the two major provinces in the EIVSP area (Nusa Tenggara Barat and Nusa Tenggara Timur)[1], and (iii) to provide training in the economic procedures for conducting these assessments. At the time of the project's implementation, the expected benefits were seen to be in the implementation of an animal health system which would assist producers increase livestock productivity, and would provide all levels of government with an effective means of planning, implementing and monitoring disease control/eradication programmes. Overall, these achievements would assist in the formulation of long-term livestock development programmes (EIVSP Implementation Document 1990).

The livestock sector in eastern Indonesia has become a focus of government attention because it is an important source of breeding stock and meat into the rapidly expanding Jakarta market. National meat per capita consumption has doubled over the last 20 years to 5.5 kg per annum. The project area is important for livestock production because its dry climate makes it generally unsuited for cropping, and now has about 30 per cent of the Indonesian cattle and buffalo populations. Livestock (particularly cattle) are also seen as a means of improving the living standards of the predominantly subsistence farmers in the drier areas of the country. However, Indonesian livestock productivity is significantly affected by many major animal diseases including Brucellosis in cattle and buffalo, Newcastle Disease in poultry and parasitism in all livestock species. Major productivity losses result from animal mortality but these are exceeded by morbidity-induced losses from the non-fatal diseases. With certain diseases, economic costs also result from the government restrictions on the transfer of breeding stock from disease-affected areas, while other costs are the reductions in the social and religious values of animals, and in their importance as store capital (Winrock 1986). Disease control in the Indonesian livestock sector is the responsibility of government (except in intensive livestock operations). The establishment of government priorities reflects a reaction to emergencies (such as the 1983 Foot and Mouth Disease outbreak), the economic importance of the disease and the prospects for its control, and the overall constraints on government expenditure on disease control programmes (Parsons and Vere 1984).

HS is a highly infectious respiratory disease of cattle, buffalo and goats, and results in the rapid death of approximately 80 per cent of affected animals (survivors develop a strong immunity). The disease is economically significant throughout the eastern islands region because the livestock most affected (cattle and buffalo) are the most important animals to the local farmers. Official records indicate a low incidence of HS but specialist opinion suggests that these data do not reflect the true status of the disease since precise disease identification is difficult and the lack of laboratory diagnosis results in many cases not being reported. Experts consider that on average, five per cent of young animals died every year from HS,

[1] Nusa Tenggara Barat (NTB) includes comprises Lombok and Sumbawa islands; Nusa Tenggara Timur (NTT) includes the islands of Flores, Sumba and West Timor. East Timor became part of the project area in early 1992.

but mortality is increased to between 10 to 30 per cent in an outbreak[2]. Young animals are more susceptible than old animals and buffalos are more affected than cattle .

In 1991, the Indonesian Government (GOI) allocated funds for a three-year HS mass vaccination programme on Sumbawa following the success of a similar earlier programme on Lombok. The GOI's involvement arose because farmers were considered to be undertaking a socially deficient level of HS control (by vaccination) because of the high costs and a general lack of experience in disease recognition and prevention. Further, there were other national disease control policies whose implementation depended on the outcome of the HS programme. Not only were the farmers seen to benefit from the programme but HS eradication was also part of other government priorities concerning increasing protein supply to an expanding population and increasing the supply of breeding cows for redistribution programmes. This programme aims to vaccinate some 350,000 animals over six months old, of which 70 per cent are cattle and buffalo. An economic analysis of this programme estimated benefit-cost ratios between 0.7:1 and 3.5:1 and corresponding net present values of $A0.1 and $A0.652 million (at 10 per cent discount) for various mortality rate reductions (Patrick and Vere, 1992). Because HS presents a similar problem to the beef production systems throughout the region, the GOI is likely to consider extending this programme after the Sumbawa experience.

The following sections present an **ex ante** assessment of the potential economic impacts an expanded HS control programme throughout the eastern islands, including the Bali and Sulawesi regions. The main objective of this assessment is to determine the levels and distribution of potential benefits from the expanded control programme.

3. Methods

Anderson and Parton (1983) maintained that the **ex ante** assessment of agricultural research and technology was analogous to an investment analysis in which the future flows of diverse and uncertain benefits and costs had to be projected. Complexities were introduced by the need to elicit potential outcomes and adoption levels, the public good nature of the programme, and in identifying its eventual beneficiaries. Of the various **ex ante** assessment techniques (such as scoring models, mathematical programming models, production function and system approaches, and benefit-cost methods), benefit-cost analysis was considered to be the most practical. Where the main concern of this type of assessment is to evaluate the social benefit changes from technology adoption, an appropriate value measure is required. In benefit-cost analysis, Randall (1980) suggested that economic surplus was the appropriate measure. Norton and Davis (1981) regarded the **ex ante** estimation of benefit-cost ratios and rates of return to proposed research as being conceptually similar to technology impact assessments based on economic surplus measurements. Models embracing the benefit-cost and economic surplus approaches have been widely applied (in various forms) to research

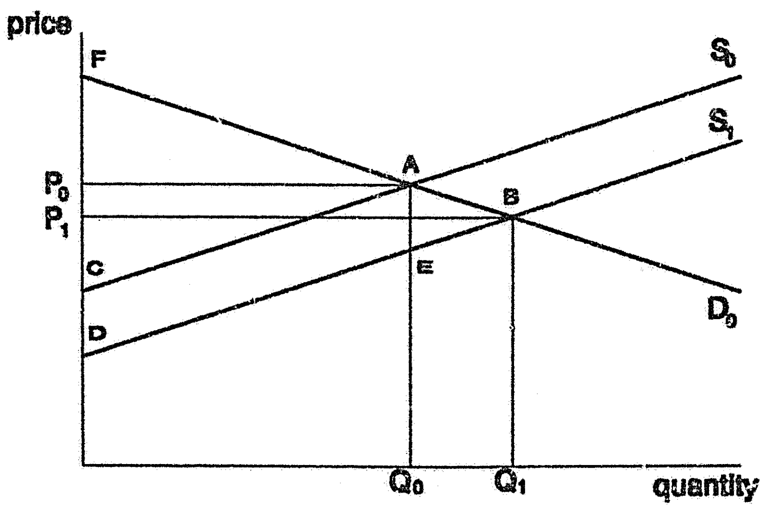
[2] These estimates were provided by Drh. Muthalib, Head, Animal Health Section, Department of Livestock Services for NTB province, and Drh. Djaya, Head, Animal Health Laboratory, West Timor.

evaluation and technology impact assessment (Antony and Anderson 1991). These models assume that new technology adoption increases production which, under certain conditions, can be translated into measures of benefits and their shares between producers and consumers. When the programme costs are also considered, the estimated benefits can be projected over time and discounted to present day values to yield the social net present values, benefit-cost ratios and internal rates of return. The two approaches are therefore closely allied in the ex ante sense and this association is strengthened where the distribution of potential benefits is an important consideration.

The economic impact of livestock disease control depends on disease attributes (virulence, and morbidity and mortality effects), the characteristics of the production systems affected and the nature of market for the disease-affected product. These considerations indicate that the main economic components of the HS control programme assessment are, (i) the market impacts in terms of the level and distribution of benefits from the increased beef supplies post control, and (ii) the timing of the benefits and costs over the programme period.

The first component was assessed using an economic surplus model which assumed that the expected benefits from HS control were equivalent to the value of loss prevented over the beef animal population throughout the eastern islands. Because HS control increases beef productivity by reducing per unit production costs, control was expected to generate economic benefits in terms of the economic surplus changes resulting from the beef supply increase. Because there have been no quantitative studies of the beef markets in this region, two market situations were considered based on different elasticity conditions[3]. The first situation (market situation 1) is illustrated in Figure 1 with normally sloping supply and demand curves under which the expanded supply of beef from HS control reduces beef prices and results in economic surplus increases to both producers and consumers.

Figure 1: General economic surplus model; parallel supply shift



[3] While the elasticity magnitudes have little effect on the overall benefit levels from HS control, they directly influence benefit shares and this is an important consideration in the sponsorship of the control programme.

This market scenario assumes a closed economy equilibrium situation because beef animals sold in the region are either exported live or mainly retained for breeding, slaughter and breeding stock face the same market prices. Beef production from cattle and buffalo is Q_0 for which consumers pay a price of P_0. Producers have an economic surplus equivalent to P_0AC while consumer surplus is the area P_0AF. The adoption of the HS control technology reduces per unit production costs and shifts the beef supply curve outwards to S_1, resulting in greater output at a lower price. Here, the beef demand curve D_0 remains stationary since the additional output is assumed to face the same demand as all other beef. The area of economic surplus is now **FBD** comprising increased consumers' and producers' surpluses of P_1BF and P_1BD, respectively, which represent the impact of the HS control technology adoption on both consumers and producers. The net change in economic surplus is equivalent to the benefits of production technology adoption. It is given by the area **CABD**, the difference between the areas **FAC** and **FBD**. The incremental benefit area **CABD** incorporates the production cost reductions for the initial output Q_0 (the area **CAED**), and the area **ABE** which is the economic surplus change from the extra production at S_1, net of production costs. Where the supply curve shift is parallel so that the vertical distance between the two supply curves is constant, the changes in the economic surplus areas from the adoption of HS control are given (from Alston 1991) as;

Change in consumers' surplus;

(1) $\Delta CS = P_0Q_0Z(1 + 0.5Z\eta)$

Change in producers' surplus;

(2) $\Delta PS = P_0Q_0(k - Z)(1 + 0.5Z\eta)$

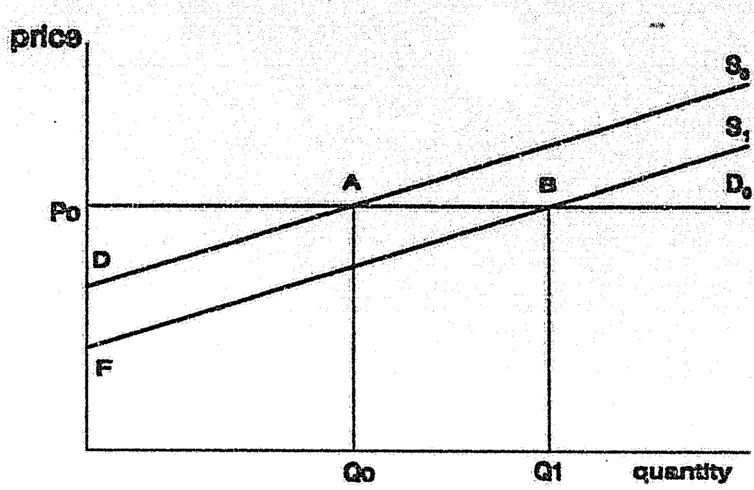
Change in total surplus ($\Delta CS + \Delta PS$);

(3) $\Delta TS = P_0Q_0k(1 + 0.5Z\eta)$

where, P_0 and Q_0 are the initial equilibrium beef market-clearing price and quantity, Z is the percentage reduction in price from the beef supply shift defined as $Z = k\varepsilon/(\varepsilon+\eta)$, k is the vertical supply shift expressed as the percentage reduction in the variable costs of beef production from controlling HS, and ε and η are respectively, the price elasticities of supply and demand for beef.

The second situation (market situation 2) assumes a highly elastic beef demand (Figure 2) under which prices are not affected by the post-control production increases. The reasoning here is that Indonesian per capita meat consumption is low (about five kg per year) and meat is therefore highly substitutable in consumption. Under this market situation, the beef demand elasticity (η) has an infinite value ($-\infty$), the beef price reduction (Z) approaches zero, and producers derive all the benefits from HS control because the coincidence of the beef price line and demand curve means that there is no consumers' surplus.

Figure 2: The change in consumer surplus due
to a shift in supply under the assumption of perfectly elastic demand



The change in total (producers') surplus is the area **DABF** which (after Edwards and Freebairn 1981) is given as;

Change in total and producers' surplus;

(4) $\Delta TS(=\Delta PS) = kQ_0 + 0.5k(Q_1 - Q_0)$

$= 0.5k(Q_0 + Q_0)$

where, Q_0 and Q_1 represent the regional beef market before and after the HS control programme. Equations (3) and (4) measure the same area of economic surplus change but in the perfectly elastic demand situation, k is an absolute measure of the beef supply shift, expressed as the monetary reduction in the variable unit costs of beef production after control.

Equations (1) to (4) were solved to estimate the benefits in terms of the changes in economic surplus from the HS control programme for mortality rate reductions of two, six and 10 per cent. Beef quantities before and after control were calculated from the changes in output per breeding animal per annum and their respective populations[4], prices were obtained from official sources (DGLS 1990), while the beef supply shift parameter (k) was derived from gross margin budgets of standard beef production systems for average mortality rate reductions (Patrick and Vere 1992). The main data deficiency related to the supply and

[4] The cattle and buffalo populations in the project area were 3.1 million and 0.98 million, at the last official census (DGLS 1991).

demand conditions in this regional beef market in the absence of supporting empirical analysis.

There are conflicting estimates of meat demand parameters in Indonesia and other developing Asian countries. Indonesian meat demand elasticities range from -1.09 (Deaton 1990) to -0.53 Sabrani (1982), while those for composite meat, poultry and dairy consumption average about -0.91 (Johnson et al. 1987). There is less evidence of meat supply response to price changes. One Philippines-based study by Estrada and Bantilan (1992) reported subjectively-derived beef supply price elasticities of around 0.5, while Davis, Oram and Ryan (1987) recorded similarly large estimates for sheep and goat meat (which is a close consumption substitute for beef) in Asia. A range of elasticities was used for the first market situation. Demand elasticities (η) from unity to -0.53 followed the Deaton, Johnson et al. and Sabrani studies, while the supply elasticity (ε) ranged between 1.5 (after Davis, Oram and Ryan for sheep-goat meat) and a relatively inelastic estimate of 0.5 after Estrada and Bantilan and the observation that market price is a minor consideration in the farmers perceived value of cattle and buffalo (Winrock 1986).

To assess the second component, the estimated benefits and costs of the HS control programme were projected over ten years and discounted to calculate the net present value, internal rate of return and benefit-cost ratio investment criteria. The benefits were assumed to be equivalent to the changes in economic surplus from the control programme for the range of mortality rate reductions. Programme costs were assessed on a per cow and buffalo vaccinated basis and included supplying and administering the vaccine, and the support capital provided under the EIVSP (Patrick and Vere 1992). This gave a cost of $A 0.38 per beef animal vaccinated. The projected benefits and costs were discounted at 10 per cent nominal.

4. Results and Discussion

The estimated changes in economic surplus from HS control are in Table 1 and represent the expected annual net benefits from the effective control of HS throughout the project area. In the first market situation, the economic surplus gains ranged between $0.95 and $5.23 million according to the mortality rate reduction achieved. Both beef producers and consumers gained economic surplus in proportion to the assumed beef market elasticities. Producer gains were about double those received by consumers where the beef price elasticity of supply was low. These benefit shares were reversed in favour of beef consumers under a price elastic supply and inelastic demand. The second market situation resulted in reduced total economic surplus gains, the reason for this is unclear at this stage as both measures are providing estimates of the same total economic surplus, clearly more work must be done in this area.

The benefit-cost criteria (Table 2) indicate that the mortality rate reduction in beef brreding stock and progeny post HS control needs to be greater than two per cent for the vaccination programme to yield positive returns.

Table 1: Estimates of economic surplus of controlling HS in Eastern Indonesia at varying mortality rate reductions ($A million)

	2 % mortality reduction			6 % mortality reduction			10 % mortality reduction		
	ΔCS	ΔPS	ΔTS	ΔCS	ΔPS	ΔTS	ΔCS	ΔPS	ΔTS
Market situation 1									
(i) η=1.5, ε=1.5	0.48	0.48	0.95	1.62	1.62	3.24	2.61	2.61	5.23
(ii) η=1.5, ε=0.5	0.24	0.71	0.95	0.81	2.42	3.23	1.30	3.90	5.20
(iii) η=0.53, ε=1.5	0.70	0.25	0.95	2.39	0.84	3.23	3.84	1.36	5.20
(iv) η=0.53, ε=0.5	0.46	0.49	0.95	1.56	1.66	3.22	2.52	2.67	5.19
Market situation 2	-	0.45	0.45	-	1.44	1.44	-	2.44	2.44

The returns from HS control reflect the economic impact of this and other diseases on Indonesia's livestock sector. The estimated benefit levels are significant despite the relatively small reductions in unit beef production costs (0.6 to 3.3 per cent) and hence, beef supply curve shifts (defined in these terms) that can be attributable to HS control. Overall, the benefits represent about two per cent of the value of livestock production in the region. There are also important welfare implications in the programme, individual animals are very important to smallholders and any cow mortality has severe repercussions to their asset base and livelihood.

Table 2: Results of benefit/cost analysis for HS control in Eastern Indonesia

	2 % mort. reduction	6 % mort. reduction	10 % mort. reduction
Market situation 1			
NPV ($ million)[a]	0.92	14.1	25.57
IRR (%)	7.1	132.3	263.7
B/C ratio[a]	1.16:1	4.1:1	6.62:1
Market situation 2			
NPV ($ million)[a]	-1.98	3.72	9.5
IRR (%)	N/A	29.5	83.2
B/C ratio[a]	0.57:1	1.82:1	3.09:1

[a] discounted at 10 per cent.

These types of assessments are indicative of the growing requirement of governments and the aid organisations for economic evaluations in assisting funding decisions in animal health improvements in the developing countries. HS is one of many important livestock diseases to which the GOI has undertaken a commitment to control. However, the demonstration of economic returns to the control of a specific disease is only one input in making resource allocation decisions within the overall government budget for controlling disease and other forms of investment in the agricultural sector. Other considerations (political and strategic) are usually also importnat factors which explains why at times low-benefit programmes may attract funding while those with potentially much higher returns may not. Hence, the level of programme evaluation required in these situations extends beyond the identification and comparison of potential benefits and costs. Also required are indications of the social and demographic implications and the ability of the existing institutional framework to accomodate the project proposal.

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